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Clyde River Environmental Flows:

IFIM Evaluation of Minimum Flows

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1. Introduction

This report describes an initial assessment of environmental flow requirements of the Clyde River. The Instream Flow Incremental Methodology (Bovee 1982, Jowett 1992, Stalnaker et al. 1995) is used to derive relationships between habitat availability for instream fauna an discharge. These relationships are then used in a risk assessment approach developed by Davies and Humphries (1996) and used for a variety of environmental flow assessments in Tasmania. This study focuses only on minimum flows for the irrigation (‘summer’) season, and does not attempt to derive an environmental flow regime for the Clyde, which would require a more extensive study.

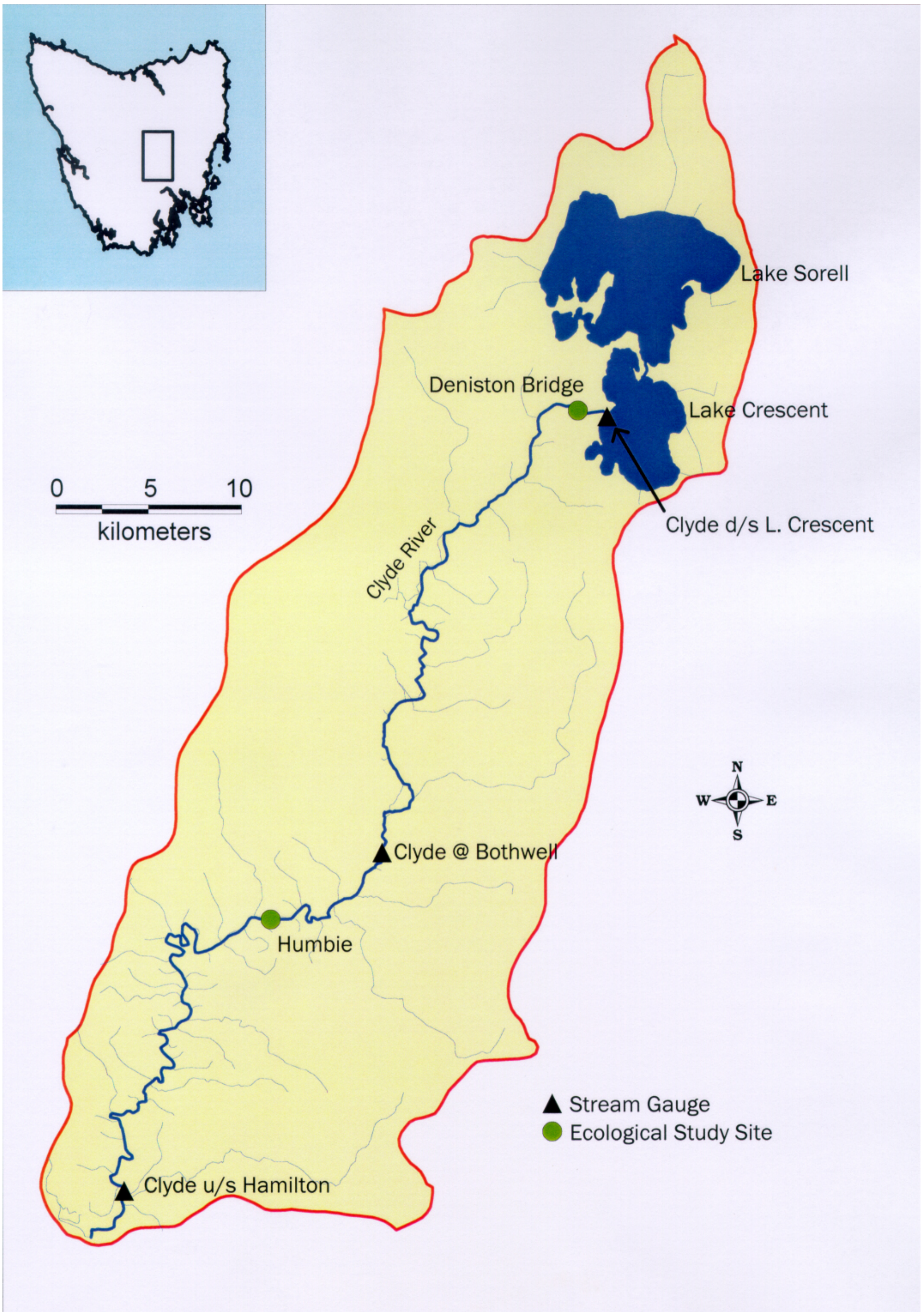
2. Methods

2.1 Site transect data

Two study sites had been established by DPIWE Resource Assessment Branch, on the upper and lower Clyde River (see Figure 1.) At each site, a series of transects were established across the channel in locations representative of differing habitat types present. 12 transects were established at the Humbie site, and 10 at the Deniston Bridge site (on Black Snake Rd).

Transect data collected over several discharges was provided to Freshwater Systems by DPIWE. These data were checked, and where necessary corrected for errors. Data consisted of transect offsets, depths, velocities and substrate composition, water surface and datum peg elevations, and inter-transect distances.

Figure 1. Map of Clyde River showing locations of the two environmental flow study sites.



All habitat analysis and hydraulic simulation was conducted using the RHYHAB package (Jowett 1992). All data was checked using the RHYHAB data checking routine, and any errors corrected. Discharge estimates for each transect were examined and evaluated for any significant deviations from the mean site discharge value. This required minor corrections to velocity values at four offsets in only one transect.

After data entry and checking, velocity distribution factors (vdf's) were manually adjusted in RHYHAB for those transect offsets which were dry when the site was gauged. These were checked against values from the higher gauging for the Deniston Bridge site, requiring only minor correction.

2.2 Hydraulic simulation

Two simulation methods were attempted, using the RHYHAB package - water surface profiling (WSP) and rating-based (RB) simulation. Attempts to conduct WSP simulation for Deniston Bridge site were unsuccessful, due to excessively large Manning's N values. This was largely due to excessively large site slopes, and attempts to derive suitable Manning's N values by correcting site levels were unsuccessful. WSP simulation was successful for the Humbie site after addition of additional riffle control transects downstream of pool transects. Profile data for transect 7 was used for these 'dummy' controls, as it was close to the average profile for all riffle transects, and was felt to represent typical downstream hydraulic controls for pool sections within the reach. Ideally, additional downstream control transect data should be collected in the field.

RB simulation was successfully attempted for both sites. The availability of a higher flow gauging for the Deniston Bridge site allowed ready fitting of a rating curve, with both flow ratings agreeing well with rating curves based on Manning's equation, for each transect. For the Humbie site, ratings derived from Manning's equation (with beta of zero) agreed well with ratings derived from WSP modeling. Simulated profile velocities were examined and appeared logical. In the absence of higher flow gaugings, these observations were taken as evidence that the rating curves for the

Humbie transects were reasonable approximations to real ratings over the flow range 0.1- ca 2 cumec.

Additional checks on simulation included:

- examination of all simulated velocity profiles for each transect at each simulated discharge;
- ensuring that all transect ratings fell above critical flow curves;
- examination of any RHYHAB messages during simulation runs on limiting calibrations and/or island formation and re-inspection of simulation output for errors or inconsistencies.

2.3 Biological habitat simulation

Macroinvertebrate habitat preference data was provided for abundance of individual taxa, total abundance and number of taxa by DPIWE. Trout habitat preference curves were taken from the literature (Raleigh et al. 1986) for adult, juvenile, young of the year, fry and spawning. All curves were inspected in RHYHAB prior to use, to check for potential errors.

Habitat simulation was conducted over a range of flows from the lowest that could be successfully simulated (0.01 cumec for Deniston Bridge and 0.1 cumec for Humbie), up to and slightly above the range of post-irrigation median of mean monthly flows for each site. Simulation was conducted in either 0.01 or 0.1 cumec steps. Simulation results, as weighted useable area (WUA) of habitat at each discharge were examined graphically prior to use.

Outputs from simulation were transferred to Excel files for further analysis.

2.4 Risk analysis

The risk analysis was conducted using the same approach described by Davies and Humphries (1996) for the South Esk basin.

The analysis was conducted as follows:

1) Mean monthly flows were provided by DPIWE for Humbie and Deniston Bridge (Black Snake Rd) for the period 1966 to 1999 inclusive, modeled as natural flows (modeled flows without irrigation) and as current irrigation flows (with values adjusted by catchment area ratio from the Hamilton record). Natural flows were modeled as described in the attached Appendix 1, using relationships between Clyde and Jordan River flows.

2) The overall median of mean monthly flows was calculated from the period of record for each month, for both natural and irrigation flows.

3) For several nominal (simulated) flows in each month, the % deviation of habitat availability (WUA) at nominal flow from the WUA at natural flows (the median of mean monthly natural flows for that month) was calculated using the following formula:

$$\%\Delta HA = 100*(WUAQnom - WUAnat)/WUAnat$$

where WUAQnom = WUA at nominal discharge, WUAnat = WUA at natural flow (median of mean monthly flows for that month in the modeled natural flow record).

This was done for the following biological ‘values’:

- total abundance of macroinvertebrates;
- number of macroinvertebrate taxa (‘diversity’);
- abundance of individual macroinvertebrate taxa;
- brown trout adults, juveniles, fry, young of the year, spawning.

This represents nine risk categories in total. Risks for individual macroinvertebrate taxa were combined into one category, as indicated below in Table 1. This places the emphasis on the overall impact on the macroinvertebrate community rather than focusing on individual species and making arbitrary trade-offs between them. Categories for the individual life stages of trout were kept separate due to the importance of each life stage to maintenance of a viable population and fishery, and acknowledging the distinct habitat requirements of each stage.

4) Each value of habitat deviation (%ΔHA) was converted to a risk category, according to the criteria established by Davies and Humphries (1996), as shown in Table 1. For this analysis, the risk assessed is the risk of failure to maintain biota due to loss of habitat availability relative to natural conditions (i.e. at natural flows).

Table 1. Risk categorisation criteria for biological values in the Clyde River. %ΔHA = % difference (positive or negative) in WUA between nominal flow and natural flow (mean monthly flow for that month under natural conditions).

Risk category:	1	2	3	4
Biological Values	**No risk or beneficial**	**Moderate risk**	**High risk**	**Very high risk**
Total macroinvertebrate abundance and number of taxa; trout life stages; wetted area of stream bed.	> - 15% %ΔHA change from natural flows i.e. > 85% of habitat under natural flows	- 40% to -15% %ΔHA change from natural flows i.e. 60 – 85% of habitat under natural flows	- 70% to -40% %ΔHA change from natural flows i.e. 30 - 60% of habitat under natural flows	< - 70% %ΔHA change from natural flows i.e. <30% of habitat under natural flows
Individual macroinvertebrate taxa.	< 10% of taxa with %ΔHA < -25% i.e. with < 75% of habitat under natural flows	10 - 25% of taxa with %ΔHA < -25% i.e. with <75% of habitat under natural flows	25 - 50% of taxa with %ΔHA < -25% i.e. with <75% of habitat under natural flows	> 50% of taxa with %ΔHA < -25% i.e. with <75% of habitat under natural flows

5) The final risk assessment for each nominal discharge was conducted in two ways:

5a) Risk relative to 'natural' conditions

This was conducted by taking the highest risk score across all nine risk categories as the risk, and identifying the lowest discharge associated with that risk as being the recommended minimum mean daily flow for each month. This is an inherently conservative approach, in order to minimise risk to the biota. Trade off between risk levels for different biological values in the absence of specific management targets favouring particular species/biotic groups is an inherently subjective and semi-arbitrary process and should be avoided.

5b) Risk relative to current 'modified' conditions

A management objective of this approach is to maintain the risk to biota within levels that are currently observed. Thus, risks should be no greater than occur under existing median mean monthly flows. For this purpose, the median of recorded mean monthly flows for the Clyde was used for each calendar month derived from the period 1990 to 1999. For each month, the risk level for this discharge was identified and the next lowest discharge which still maintained that risk level selected. This is then recommended as the minimum mean daily flow for that month.

3. Results

3.1 Flow and habitat simulation

No problems were encountered with either flow or habitat simulation using the rating method after relevant adjustments and corrections (see above).

3.2 Risk assessment and minimum flows

%∆HA values for all biota at each site and each simulated discharge are shown in Appendix 3. Risk scores for all biological values are shown in Appendix 2.

Overall risk assessment results for Humbie and Deniston Bridge are shown in Tables 2 and 3, respectively. Each table also shows recommended minimum mean daily flows for each month, derived using the two approaches – i.e. for natural and modified states. Table 4 shows the 'current' (1990 – 1999) modified flow regime as medians of mean monthly flows (from DPIWE data) for comparison with values in Tables 2 and 3.

Risk assessment clearly shows that the current flow regime is resulting in significant changes in habitat availability to a significant portion of the biota in both summer and winter. Habitat availability has generally increased significantly during summer as a result of enhanced summer irrigation flows (see Figure 2). By contrast, it has decreased during winter as due to lower than natural winter flows during irrigation off-season-possibly related to winter capture of flood flows by offstream storage and/or Lake Crescent under irrigation management, and/or winter draw-offs to lower catchment storages (Figure 2).

Significant reallocation of flows to the river during winter would be required to restore habitat availability to that which occurs under natural conditions.

If a primary management objective is maintenance of the existing modified ecosystem, then comparison of recommended minimum flows with the median mean monthly flows for 1990-99 (Table 4) reveals that there is only little opportunity to reduce winter flows further than at present without significantly enhancing risk to biota through habitat limitation.

	Q	0.01	0.05	0.10	0.22	0.30	0.50	0.70	0.80	0.90	1.00	1.50	1.80	2.00	2.10	2.40	Recommended	Minimum Q's
Month																	**Natural condition**	**Modified condition**
Jan-March	**Overall Risk**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**						**0.05**	**0.05**
	N (of 9)	9	9	9	9	9	9	9	9	9	9							
April	**Overall Risk**			**1**	**1**	**1**	**1**	**2**	**2**	**2**							**0.10**	**0.10**
	N (of 9)			9	9	9	9	1	1	1								
May	**Overall Risk**			**4**	**1**	**1**	**1**	**2**	**2**	**2**	**2**						**0.22**	**0.22**
	N (of 9)			1	9	9	9	1	1	1	1							
June	**Overall Risk**			**4**	**3**	**3**	**1**	**1**	**1**	**1**	**1**						**0.50**	**0.42**
	N (of 9)			1	2	2	9	9	9	9	9							
July	**Overall Risk**					**3**	**3**	**3**	**2**	**2**	**2**	**1**					**1.50**	**1.50**
	N (of 9)					7	4	1	6	4	3	9						
August	**Overall Risk**					**3**	**3**	**4**	**3**	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**2.00**	**2.00**
	N (of 9)					7	6	2	1	1	1	2	2	9	9	9		
September	**Overall Risk**					**3**	**3**	**4**	**3**	**3**	**2**	**1**	**1**	**1**	**2**		**1.50**	**1.50**
	N (of 9)					7	6	1	1	1	5	9	9	9	1			
October	**Overall Risk**					**3**	**3**	**4**	**3**	**3**	**3**	**2**		**1**		**1**	**2.00**	**1.50**
	N (of 9)					7	6	2	1	1	1	2		9		9		
Nov	**Overall Risk**			**4**	**4**	**3**	**2**	**1**	**1**	**1**	**1**						**0.70**	**0.70**
	N (of 9)			1	1	5	7	9	9	9	9							
Dec	**Overall Risk**			**3**	**2**	**1**	**1**	**1**	**1**	**1**	**2**						**0.30**	**0.30**
	N (of 9)			5	1	9	9	9	9	9	1							

Table 2. Risk summary and recommended minimum flows for Clyde River at Humbie. Overall risk = highest risk for biological values at this site for the month. Q = nominal (simulated) flow in cumec. N = no. of biological values (of a total of 9) at this level of risk.

Month	Q	0.01	0.1	0.2	0.3	0.5	0.7	0.9	1	Recommended Natural condition	Minimum Q's Modified condition
Jan-April	**Overall Risk**	**1**	**2**		**3**	**3**	**4**	**4**	**4**	**0.0**	**0.30**
	N (of 9)	9	1		1	1	1	1	1		
May	**Overall Risk**		**1**		**3**	**4**	**4**	**4**	**4**	**0.1**	**0.10**
	N (of 9)		9		1	1	1	1	1		
June	**Overall Risk**		**3**	**1**	**2**	**3**	**3**	**3**	**4**	**0.2**	**0.08**
	N (of 9)		2	9	3	1	1	1	1		
July	**Overall Risk**		**4**	**4**	**3**	**1**	**2**	**3**	**3**	**0.5**	**0.07**
	N (of 9)		2	1	1	9	1	1	1		
August	**Overall Risk**		**4**		**4**	**4**	**2**	**2**	**1**	**1.0**	**0.07**
	N (of 9)		1		1	1	2	2	9		
September	**Overall Risk**		**4**		**4**	**3**	**1**	**2**	**3**	**0.7**	**0.04**
	N (of 9)		2		1	2	9	3	1		
October	**Overall Risk**		**4**		**4**	**3**	**2**	**1**	**2**	**0.9**	**0.50**
	N (of 9)		1		1	2	2	9	2		
Nov	**Overall Risk**		**1**		**3**	**4**	**4**	**4**	**4**	**0.1**	**0.50**
	N (of 9)		9		1	1	1	1	1		
Dec	**Overall Risk**		**1**		**3**	**4**	**4**	**4**	**4**	**0.1**	**0.50**
	N (of 9)		9		1	1	1	1	1		

Table 3. Risk summary and recommended minimum flows for Clyde River at Deniston Bridge. Overall risk = highest risk for biological values at this site for the month. Q = nominal (simulated) flow in cumec. N = no. of biological values (of a total of 9) at this level of risk.

Table 4. Current modified irrigation flows. Medians of mean monthly flows for the period 1990 – 1999 inclusive.

Month	Current median mean daily Q	
	Humbie	Deniston Br
Jan-March	0.49-0.59	0.62 - 0.95
April	0.33	0.35
May	0.22	0.10
June	0.42	0.08
July	1.63	0.07
August	2.70	0.07
September	1.58	0.04
October	1.57	0.49
Nov	0.83	0.69
Dec	0.79	0.72

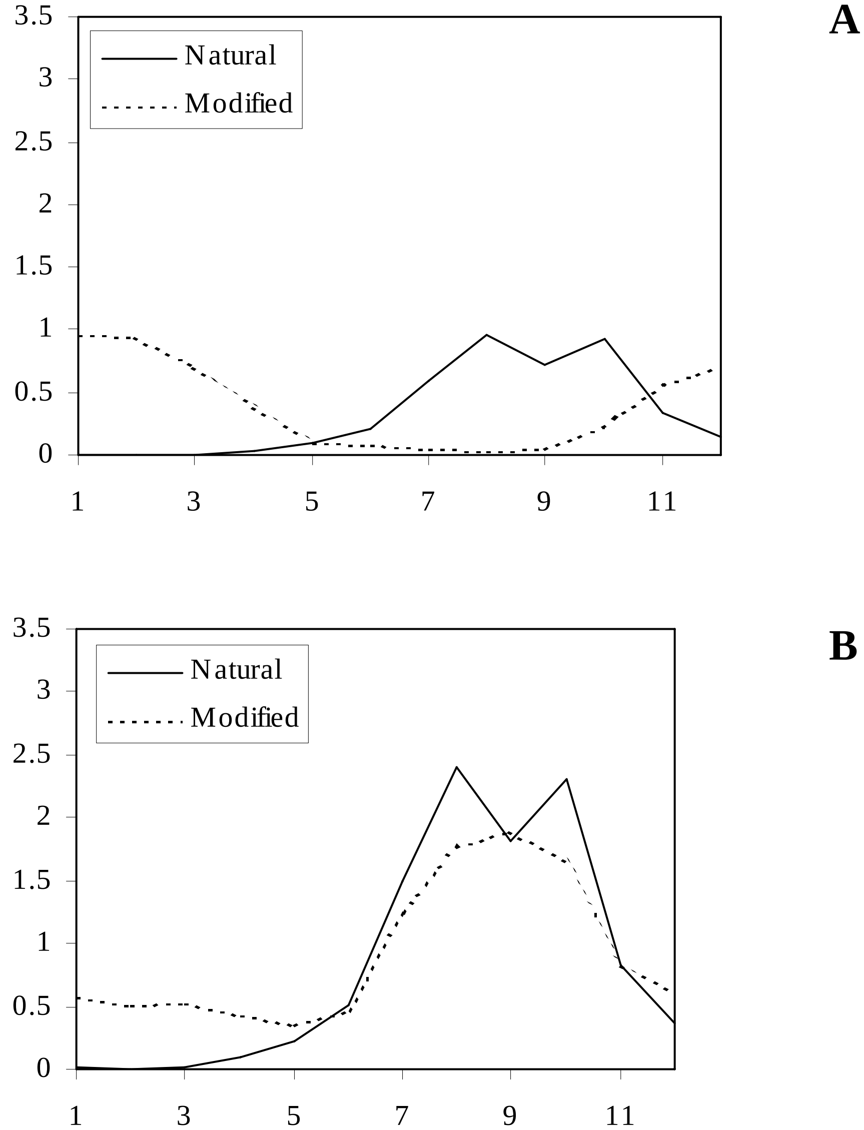


Figure 2. Pattern of natural and modified (irrigation) median of mean monthly flows at Deniston Bridge (A) and Humbie (B) for the period 1966 – 1999 inclusive.

4. References

Bovee KD 1982. A guide to stream habitat analysis using the instream flow incremental methodology. Instream Flow Information Paper No.12. US Fish and Wildlife Service. Report No. FWS/OBS-82-16. June 1982.

Davies PE and Humphries P 1996. An environmental flow study of rivers of the South Esk Basin, Tasmania. Report to Landcare, DPIWE, Hobart.

Jowett IG 1992. River hydraulics and instream habitat modeling for river biota. Chapter 14 in: *Waters of New Zealand*, NZ Hydrological Society Inc, Wellington.

Raleigh RF, Zuckerman LD and Nelson PC 1986. Habitat suitability index models and instream flow suitability curves: Brown trout. US Fish and Wildlife Service, Biological report 82 (10.124). 65 pp.

Stalnaker CB, Lamb BL, Henriksen J, Bovee K, Bartholow J 1995. The Instream Flow Incremental methodology: A Primer for IFIM. US Dept of the Interior, Biological Report 29, March 1995, Washington DC.

Appendix 1. Method of deriving natural flows.

Hydrographs of the three stream gauging stations in the Clyde catchment (Clyde d/s of Lake Crescent, Clyde @ Bothwell and Clyde u/s of Hamilton) were compared and the following conclusions were drawn:

- Flow peaks at the Lake Crescent gauge did not correlate with peaks at Bothwell or Hamilton, with the exception of a period in 1986.
- Summer flows in the catchment were dominated by releases from Lake Crescent.
- Winter flows from Lake Crescent generally contributed little to flows at Hamilton and Bothwell.

The last two conclusions could be observed from a comparison of the median monthly flows for the three sites.

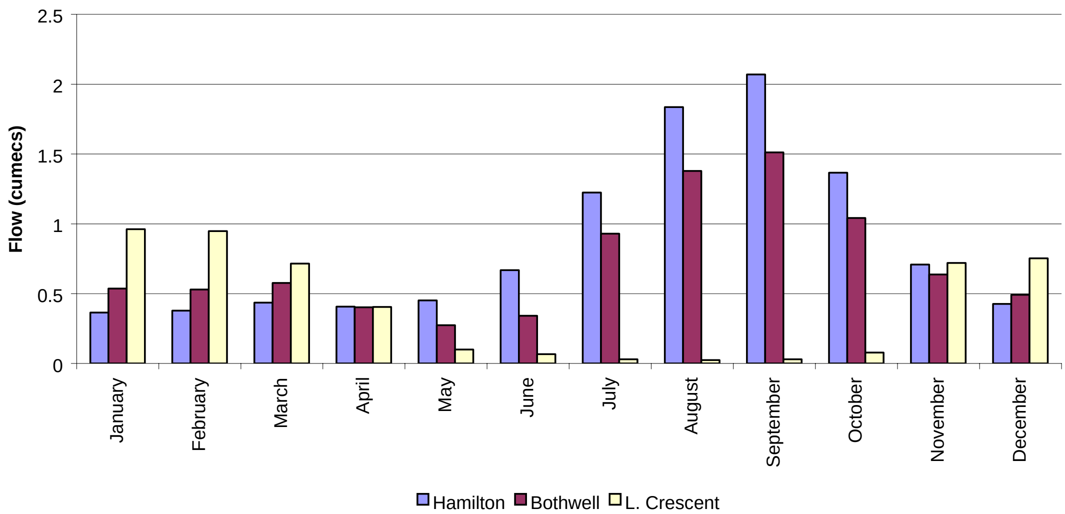


Figure 3. Median monthly flows for the three stream gauges located in the Clyde catchment

In order to predict natural flow rates for the catchment, monthly flows during the non-irrigation season (May to October) at the Hamilton stream gauge were compared with five sites, Jordan @ Mauriceton, Coal @ Baden, Tyenna @ Newbury, Pine Tree Rvt. @ Lake Hwy. and Macquarie at Trefusis. These sites were selected because of their proximity to the Clyde catchment and because their flow records were relatively unimpacted by abstraction or on-stream storages. The correlation coefficients were found to be

Table 5. Results of correlation analysis

Site	ID number	Correlation coefficient
Jordan @ Mauriceton	4201	0.936
Coal @ Baden	3203	0.778
Tyenna @ Newbury	499	0.313
Pine Tree Rvt. @ Lake Hwy.	597	0.349
Macquarie @ Trefusis	18217	0.760

Regression analysis was then used to predict natural flows at Hamilton from the Jordan at Mauriceton site's monthly flow record. Several different models were fitted to the data. Initially they were not required to pass through the origin but this resulted in exaggerated summer flow rates (ie. 1 m^3/s), so an origin restriction was applied. An exponential model provided the best fit

$$\mathbf{Ham} = 28.03 - 28.03 \times 0.84^{\mathbf{Jor}}$$

The resulting predicted monthly flow rates for the Hamilton site were then multiplied by 1.2 to account for the catchment area upstream of the Lake Crescent flow gauge.

Table 6. Actual versus modelled Hamilton flow data, monthly statistics

	Medians		Means	
Month	**Actual**	**Modelled**	**Actual**	**Modelled**
Jan	0.429	0.02	1.39	1.844
Feb	0.41	0.008	0.827	0.734
Mar	0.48	0.012	0.867	0.578
Apr	0.421	0.128	1.038	0.979
May	0.448	0.316	1.453	1.709
June	0.667	0.712	2.003	2.694
July	1.667	2.082	3.542	4.576
Aug	2.71	3.346	4.941	6.481
Sept	2.438	2.518	4.431	5.646
Oct	2.256	3.2	2.515	3.902
Nov	1.078	1.156	2.207	3.202
Dec	0.54	0.517	1.554	2.254

The near zero median monthly flows for the summer months was a realistic estimate of the natural flow conditions that would have been present in the Clyde prior to the construction of Lake Sorell and Lake Crescent, as the adjacent Jordan River is dry for most of the summer. This was supported by research conducted by historians into flow conditions in the Clyde up to the mid 1850's, prior to the construction of the two lakes.

Mean monthly natural flow estimates were calculated for the Humbie and Deniston Bridge ecological study sites using catchment area scaling of the mean monthly natural flow data set that was derived for the Hamilton stream gauging site.

Appendix 2. Risk categories by biological value.

Tabund, NTaxa = total macroinvertebrate abundance, and number of taxa. YOY = young of the year (age 0+), Juv = juvenile (age 1+), spawn = spawning habitat.

Humbie (1 of 2)

Months	Q	Wetted	Macroinvertebrates			Brown trout				
		Area	Tabund	Ntaxa	Individual taxa	Adult	Fry	YOY	Juv	Spawn
Jan-March	0.01	1	1	1	1	1	1	1	1	1
	0.05	1	1	1	1	1	1	1	1	1
	0.1	1	1	1	1	1	1	1	1	1
	0.3	1	1	1	1	1	1	1	1	1
	0.5	1	1	1	1	1	1	1	1	1
	0.7	1	1	1	1	1	1	1	1	1
	0.9	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1
April	0.1	1	1	1	1	1	1	1	1	1
	0.3	1	1	1	1	1	1	1	1	1
	0.5	1	1	1	1	1	1	1	1	1
	0.7	1	1	1	2	1	1	1	1	1
	0.9	1	1	1	2	1	1	1	1	1
	1	1	1	1	2	1	1	1	1	1
May	0.1	1	2	3	4	1	3	2	2	3
	0.22	1	1	1	1	1	1	1	1	1
	0.3	1	1	1	1	1	1	1	1	1
	0.5	1	1	1	1	1	1	1	1	1
	0.7	1	1	1	2	1	1	1	1	1
	0.8	1	1	1	2	1	1	1	1	1
	0.9	1	1	1	2	1	1	1	1	1
	1	1	1	1	2	1	1	1	1	1
June	0.1	2	2	3	4	3	3	3	3	3
	0.3	2	1	3	3	2	2	2	2	2
	0.5	1	1	1	1	1	1	1	1	1
	0.7	1	1	1	1	1	1	1	1	1
	0.8	1	1	1	1	1	1	1	1	1
	0.9	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1
July	0.3	3	1	3	3	3	3	3	3	1
	0.5	2	1	3	3	3	2	2	3	1
	0.7	2	1	2	2	3	2	2	2	1
	0.8	2	1	2	2	2	2	1	2	1
	0.9	2	1	2	1	2	1	1	2	1
	1	2	1	2	1	2	1	1	1	1
	1.5	1	1	1	1	1	1	1	1	1

Humbie (2 of 2)

Months	Q	Wetted Area	Macroinvertebrates Tabund	Ntaxa	Individual taxa	Brown trout Adult	Fry	YOY	Juv	Spawn
August	0.3	3	1	3	3	3	3	3	3	1
	0.5	3	1	3	3	3	3	2	3	1
	0.7	3	1	4	2	4	2	2	2	1
	0.8	2	1	2	2	3	2	2	2	1
	0.9	2	1	2	2	3	2	2	2	1
	1	2	1	2	2	3	2	2	2	1
	1.5	2	1	1	1	2	1	1	1	1
	2	1	1	1	1	1	1	1	1	1
	2.4	1	1	1	1	1	1	1	1	1
September	0.3	3	1	3	3	3	3	3	3	1
	0.5	3	1	3	3	3	3	2	3	1
	0.7	2	1	2	2	4	2	2	2	1
	0.8	2	1	2	2	3	2	2	2	1
	0.9	2	1	2	2	3	2	2	2	1
	1	2	1	2	2	2	1	1	2	1
	1.5	1	1	1	1	1	1	1	1	1
	1.8	1	1	1	1	1	1	1	1	1
	2.1	1	1	1	1	1	1	1	1	2
October	0.3	3	1	3	3	3	3	3	3	1
	0.5	3	1	3	3	3	3	2	3	1
	0.7	3	1	4	2	4	2	2	2	1
	0.8	2	1	2	2	3	2	2	2	1
	0.9	2	1	2	2	3	2	2	2	1
	1	2	1	2	2	3	2	2	2	1
	1.5	2	1	1	1	2	1	1	1	1
	2	1	1	1	1	1	1	1	1	1
	2.3	1	1	1	1	1	1	1	1	1
Nov	0.1	3	2	3	4	3	3	3	3	3
	0.3	2	1	3	3	3	3	2	3	2
	0.5	2	1	2	2	2	2	2	2	1
	0.7	1	1	1	1	1	1	1	1	1
	0.8	1	1	1	1	1	1	1	1	1
	0.9	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1
Dec	0.1	2	2	3	2	2	3	3	3	3
	0.37	1	1	1	1	1	1	1	1	1
	0.5	1	1	1	1	1	1	1	1	1
	0.7	1	1	1	1	1	1	1	1	1
	0.9	1	1	1	1	1	1	1	1	1
	1	1	2	1	1	1	1	1	1	1

Deniston Bridge (1 of 2)

Months	Q	Wetted Area	Macroinvertebrates Tabund	Ntaxa	Individual taxa	Brown trout Adult	Fry	YOY	Juv	Spawn
Jan-April	0.01	1	1	1	1	1	1	1	1	1
	0.1	1	1	1	2	1	1	1	1	1
	0.3	1	1	1	3	1	1	1	1	1
	0.5	1	1	1	3	1	1	1	1	1
	0.7	1	1	1	4	1	1	1	1	1
	0.9	1	1	1	4	1	1	1	1	1
	1	1	1	1	4	1	1	1	1	1
May	0.1	1	1	1	1	1	1	1	1	1
	0.3	1	2	2	3	1	1	1	1	1
	0.5	1	2	1	4	1	1	1	1	1
	0.7	1	1	2	4	1	1	1	1	1
	0.9	1	1	2	4	1	1	1	1	1
	1	1	1	2	4	1	1	1	1	1
June	0.1	2	1	2	1	3	3	1	1	1
	0.2	1	1	1	1	1	1	1	1	1
	0.3	1	2	2	2	1	1	1	1	1
	0.5	1	2	2	3	1	1	1	1	1
	0.7	1	1	2	3	1	1	1	1	1
	0.9	1	1	2	3	1	1	1	1	1
	1	1	1	2	4	1	1	1	1	1
July	0.1	3	2	1	3	4	4	1	1	1
	0.2	2	2	2	2	4	2	1	1	1
	0.3	2	2	3	1	2	1	1	1	1
	0.5	1	1	1	1	1	1	1	1	1
	0.7	1	1	1	1	1	2	1	1	1
	0.9	1	1	2	1	1	3	1	1	1
	1	1	2	2	2	1	3	1	1	1
August	0.1	3	2	1	3	4	3	1	1	1
	0.3	3	2	2	2	4	1	1	1	1
	0.5	2	2	3	1	4	1	1	1	1
	0.7	2	1	1	1	2	1	1	1	1
	0.9	2	1	1	1	2	1	1	1	1
	1	1	1	1	1	1	1	1	1	1
September	0.1	3	2	1	3	4	4	1	1	1
	0.3	2	2	2	2	4	2	1	1	1
	0.5	2	2	3	1	3	1	1	1	1
	0.7	1	1	1	1	1	1	1	1	1
	0.9	1	2	2	1	1	2	1	1	1
	1	1	2	2	1	1	3	1	1	1

Deniston Bridge (2 of 2)

Months	Q	Wetted	Macroinvertebrates			Brown trout				
		Area	Tabund	Ntaxa	Individual taxa	Adult	Fry	YOY	Juv	Spawn
October	0.1	3	2	1	3	4	3	1	1	1
	0.3	3	2	2	2	4	1	1	1	1
	0.5	2	2	3	1	3	1	1	1	1
	0.7	2	1	1	1	2	1	1	1	1
	0.9	1	1	1	1	1	1	1	1	1
	1	1	2	1	1	1	2	1	1	1
Nov	0.1	1	1	1	1	1	1	1	1	1
	0.3	1	2	2	3	1	1	1	1	1
	0.5	1	2	1	4	1	1	1	1	1
	0.7	1	1	2	4	1	1	1	1	1
	0.9	1	1	2	4	1	1	1	1	1
	1	1	1	2	4	1	1	1	1	1
Dec	0.1	1	1	1	1	1	1	1	1	1
	0.3	1	2	2	3	1	1	1	1	1
	0.5	1	2	1	4	1	1	1	1	1
	0.7	1	1	2	4	1	1	1	1	1
	0.9	1	1	2	4	1	1	1	1	1
	1	1	1	2	4	1	1	1	1	1